**Concept presentation**

**Chemistry (SCH3U)**

**Topic – Acids and Bases**

**Specific expectations covered:**

E3.5 Explain the Arrhenius theory of acids and bases

E3.6 Explain the difference between strong and weak acids, and between strong and weak bases, in terms of degree of ionization

E2.7 Determine the concentration of an acid or a base in a solution (e.g., the concentration of acetic acid in vinegar), using the acid–base titration technique.

**Background Information**:

* **Acids and bases**

Acids and bases are chemical compounds that have distinctive properties in water solution. The sour taste of a lemon, lime, or grapefruit, for example, is caused by citric acid. The slippery feel of ammonia, a common base, is characteristic of all bases. Bases tend to taste bitter. Acids and bases also change the color of certain dyes, such as phenolphthalein and litmus. Acids change litmus treated paper from blue to red. Acids change basic phenolphthalein from red to colorless. Bases change litmus treated paper from red to blue and phenolphthalein from colorless to pink.

## Neutralization

Acids and bases are sometimes described as the chemical opposites of each other .Acids and bases neutralize the action of each other. This is why we take antacids for stomach-aches, because the antacid is a base, and neutralizes the acid in the stomach.

If equivalent quantities of an acid and a base are combined, the two compounds react to form a salt and water.

For example: HCl + NaOH → NaCl + H2O

Hydrochloric acid + sodium hydroxide → sodium chloride + water

This process is known as neutralization. **The pH** is the concentration of hydrogen ions in solutions. The pH is the negative of the power of the hydronium ion in the base of ten. pH = - log10 [H3O+] **Titration** is a common laboratory technique used to determine the concentration of substances in solution.

**Lesson Template:**

|  |  |  |
| --- | --- | --- |
| Steps to be followed | Teacher’s Activity | Student’s activity |
| **Warming up**  **Activity** | Teacher may start by asking few brain storming questions related to daily life experiences.   * We have studied about   nutrition in animals, recall  what is secreted by the inner  lining of the stomach to help in the process of digestion?   * Have you ever suffered   from acidity in stomach / indigestion?   * How do we cure it? Do you remember any advertisement or an occasion at home where acidity in stomach and its cure were discussed? * Have you ever used baking soda in the kitchen? * Have you eaten salads with vinegar dressings? | Students try to think and  answer by recalling the  concepts learnt previously.  Students try to think and  answer from their experiences. |
| **Pre Content**  Acids and Bases | Teacher asks the students as to  what they understand by the  terms acids and bases? | Students have an idea about  these terms from their lower  classes, they discuss in class  and also give some examples  that they know. |

**Concept Development:**

|  |  |  |
| --- | --- | --- |
| **Specific expectation:**  E3.5 Explain the Arrhenius theory of acids and bases | * The teacher lists the properties of acids and bases as told by the students on the board * Teacher takes the students through the experience of finding the acidic or basic nature of various substances which are of daily use for example- shampoo, soap, water, tea, fruits, etc.   Activity 1 will be done with the students  Following video may be shown to the students so that they have fun while learning  http://www.youtube.com/watch?v=  zTLiJE-j1-I&feature=related | The students will be able  to-  Describe acids and bases in terms of H+ and OH-  Distinguish between acids and bases on the basis of their behaviour towards  litmus indicator.  Categorize substances as acidic or alkaline?  Worksheet:1 |
| **Specific expectation:**  E3.6 Explain the difference between strong and weak acids, and between strong and weak bases, in terms of degree of ionization | **ACTIVITY-2**  **Learning objectives:**  The students will be able to define,  dissociation, electrolyte,  non-electrolyte.  Predict if a compound is an  electrolyte or a non-electrolyte.  Explain how an electrolytic solution completes the circuit in a  conductivity apparatus so that the  light bulb glows.  Distinguish between strong and  weak acids and bases in terms of the extent of dissociation, reaction with water and electrical conductivity and pH. | Take any popular soft  drink which promises to  replenish your body's  electrolytes when you  drink it. Use the internet  to research which ingredient(s) are contained that make this drink an electrolytic solution. Also research how the body uses  electrolytes and why  they need to be replenished after exercise.  Worksheet-2 |
| **Specific expectation:**  E2.7 Determine the concentration of an acid or a base in a solution (e.g., the concentration of acetic acid in vinegar), using the acid–base titration technique | One applicable science demonstration presented interactively to the class (e.g. video, series of photos with presenter doing the demos)  This science demonstration is adapted from the site mentioned with the activity. | This video explains Acid –Base Titration step by step.  After watching the video students will write answers to the questions in the space provided on the Activity Sheet. |
| Extension | Teacher initiates an investigation by asking a guiding question.  **Chemistry Investigation**  Guiding Question: "Which is the most effective antacid?" | Students formulate  hypothesis, decide on  the variables and reach  conclusions to be shared  in groups.  Peer evaluation by  taking feedbacks from  other groups. |

**Student difficulties and common misconceptions:**

**Adapted from:** <http://www.okstate.edu/jgelder/acidPage25.html>

**1.** Many substances that contain H that are not acids and many substances that contain OH are not bases. Table sugar (sucrose), C6H12O6, contains H and OH, however, when dissolved in water it dissolves as intact molecules and does not ionize to produce any H+ or OH- ions, Since sugar molecules do not lose any H+ or OH- ions, sugar is not considered an acid. Alcohols have a characteristic hydroxyl group, OH, covalently bonded to the rest of the molecule. When alcohols dissolve in water they also dissolve molecularly and do not ionize. Since no OH- ions are released, alcohols are not bases.

**2.** Although chemists commonly refer to acids and bases as proton donors and proton acceptors, it is important to realize that H+ is being moved from one chemical species to another, not a proton from one nucleus to another.

**3.** Students may use concentrated and strong interchangeably- this is wrong! Reinforce that ‘concentrated’ (having a high concentration of particles in mol/L) is different from ‘strong’ (dissociates 100%) and ‘weak’ (dissociates much less than 100%) is different from ‘dilute’ (having a low concentration of particles in mol/L).

**4.** Students may think a neutralization of a substance requires just an acid and a base; however, it must be a strong acid and a strong base to neutralize a substance.

###### **Teaching Ideas and Strategies:**

1. Check students’ prior knowledge about the topic ‘Acids and Bases and their Properties’ by brainstorming.

2. Make connections to real life situations, for example, acidic foods and drinks are harmful for teeth so avoid pops and sour candies and also applications of acids and bases, such as vinegar is used in pickled vegetables.

3. Use molecular models or computer animations to illustrate splitting into ions for Arrhenius’ theory. If not available, use Styrofoam balls and toothpicks or small plastic building blocks. Be sure to be consistent in your choice when representing H+ and OH-.

4. Before starting the titration lab, review safety precautions and perform a quick review to check how well students are at determining the concentration of a diluted solution from a standard solution before they perform any calculations.

5. It is essential to explain ionization and dissociation based on Arrhenius Theory and use demonstration of electrolysis of HCl, NaOH etc.

6. To show how pH and acidity are related, carry out a mini investigation using everyday life examples, such as shampoo, bleach, liquid detergent etc.

**ACTIVITY-1**

**Learning objectives:**

The students will be able to-

* Distinguish between acids and bases on the basis of their behavior towards litmus indicator
* Distinguish between acids and bases on the basis of their behavior towards homemade indicators-turmeric, red cabbage etc.
* Describe acids and bases in terms of H+ and OH-.

Teacher will conduct activity to test a variety of substances to see if they are acidic or alkaline using litmus paper as an indicator.

Teacher will explain the Arrhenius concept of acids and bases:

According to one of the modern theories of acids and bases (Arrhenius concept), An acidis a

substance which give hydrogen ions in aqueous solution for e.g. HCl (Hydrochloric acid),

H2SO4 (Sulphuric acid) etc. Substances like C2H5OH (ethyl alcohol), C6H12O6 (glucose) etc. though contain hydrogen are not acidic as they do not produce hydrogen ion when

dissolved in water.

**Base** is a substance which give hydroxyl ions in aqueous solution For e.g. NaOH (sodium

hydroxide), NH4OH (ammonium hydroxide) etc are bases. Substances like C2H5OH (ethyl

alcohol) contains -OH group but it does not ionize in the aqueous solution to give OH- ions.

Hence, it is not a base.

Students will be asked to complete the following worksheet.

The following questions are inquiry or investigation based; they will initiate the thought process of the students. If the concepts are well understood then the students will be able to apply and communicate.

**WORKSHEET 1**

1. The Invisible Ink Demonstration can be done at the end of this lesson as an evaluation of the students' learnings during the lab activity. Students will be required to explain the invisible ink demo and this will require that they apply their knowledge of indicators acids and bases.

(Dip cotton swab into the vinegar & use it to write your secret message on the paper. Allow about 1-2 min for the message to dry completely. Read the "invisible ink" message by misting it lightly with the spray bottle filled with red cabbage juice or any indicator)

2. Are most house cleaning substances acids or bases? Are most food product acids or bases?

3. Disappearing "blood" squirt guns and disappearing ink pens are available in toy stores. Both use indicators and acid/base chemistry. What indicators and acidic or basic solutions would give you such effects?

4. Is methanol basic in nature? Why or why not?

5. Is ammonia acidic in nature? Why or why not?

The following video will be shown to initiate the topic of weak and strong acids and bases:

<http://www.youtube.com/watch?feature=player_detailpage&v=kcPjY9cQpWs>

A thoughtful question will be posed:

Acetic acid has 4 hydrogen atoms, then also only one of them dissociates. Why?

**ACTIVITY-2**

**Learning objectives:**

The students will be able to define dissociation, electrolyte, non-electrolyte, pH, neutralization.

Predict if a compound is an electrolyte or a non-electrolyte.

Ex plain how an electrolytic solution completes the circuit in a conductivity apparatus so that the light bulb glows.

Distinguish between strong and weak acids and bases in terms of the extent of dissociation, reaction with water and electrical conductivity.

Teacher will conduct a lab activity with the students to initiate the investigation process

**Type of activity: Inquiry based**

Using a conductivity apparatus, ask students to explain how they might complete the

circuit so that the light bulb will glow. Are there any materials that they can think of that

can conduct electricity?

**Materials Required:**

Two nails, Cork, Beakers, Source of electricity (6 Volt battery),appropriate volumes of the following solutions:

* 1.0 M HCl
* 1.0 M NaOH
* distilled water
* solution of sugar and water
* vinegar

1. Fix two nails on a cork and place the cork in a beaker.

2. Connect the nails to the two terminals of 6 volt battery through a bulb and switch.

3. Pour some HCl in the beaker and switch on the current.

4. Observe what happens. Does the bulb glow.

5. Repeat the experiment separately with NaOH, distilled water, sugar solution and

vinegar.

6. Record observations.

**Observations:**

|  |  |  |
| --- | --- | --- |
| **Solution** | **Intensity of light bulb**  **(very bright, bright, dim)** | **Conducts Electricity?**  **(yes / no)** |
| NaOH |  |  |
| Distlled Water |  |  |
| Sugar solution |  |  |
| Vinegar |  |  |
| HCl |  |  |

**Conclusion:**

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**Worksheet-2**

1. Why does the light bulb glow more brightly when the electrodes are immersed in solutions of HCl and NaOH then in vinegar?

2. Why is it dangerous to use electrical appliances in wet areas? ie: using a hairdryer while sitting in the bathtub!

3. Why the light bulb glowed when the electrodes were immersed in solutions HCl, NaOH and vinegar but not in sugar solution and distilled water.

4. Why does NaCl (aq) conduct electricity, but NaCl (s) does not?

5. List at least three household products that would be considered electrolytes.

After the discussion with the students, the teacher will generalize that a strong acid/base is

an acid/base that is almost completely dissociated into ions in its aqueous solution. Such

an acid/ base shows high conductivity

A weak acid/base is an acid/base that is weakly dissociated i.e., partially dissociated in its

aqueous solution. Such an acid/base shows low conductivity.

The teacher will ask the students to list some commonly used weak acids, strong acids, weak bases and strong bases.

The following videos are a good source to understand the pH of substances and decide whether they are acidic or alkaline, which will be shown to the students:

<http://www.youtube.com/watch?v=fHd7wRkJNgI&feature=related>

<http://www.youtube.com/watch?v=M8tTELZD5Ek&feature=related>

**This science demonstration is adapted from** [**http://www.youtube.com/watch?v=pFGXamBiFrk&feature=related**](http://www.youtube.com/watch?v=pFGXamBiFrk&feature=related)

This video explains Acid –Base Titration step by step.

After watching the video write answers to the following questions in the space provided on the Activity Sheet.

pH Scale Activity

Break students into groups of 3-4. Give them a stack of cards that list a variety of common household items and ask the students to put them in order of increasing acidity and decreasing alkalinity.

Students can use their knowledge of the properties of acids and bases to estimate the relative acidity/alkalinity of a substance.

Once students are familiar with the Arrhenius definition of acids and bases, introduce the hydrogen ion concentrations of the various substances. Students should be able to see the relationship between pH and the hydrogen ion concentration for those pH's which are integers. Ask students to describe this relationship or to determine the mathematical definition of pH depending on their background and achievement level in math.

**Extension**   
Collect a variety of the substances and ask students to verify the pH of each of the substances using a pH meter.

**ACID-BASE TITRATION**

Purpose: To determine the concentration of solution of sodium hydroxide by acid-base titration

**Materials:**

1. 250 mL beakers
2. 250 mL Erlenmeyer flask
3. 50 mL burette
4. Standardized solution of hydrochloric acid
5. Unknown solution of sodium hydroxide
6. Phenolphthalein

**Procedure:**

1. Prepare a data table as shown. Record all of your experimental results in the table as soon as you obtain them.
2. Remember to clean ALL glassware before you use it.
3. Obtain about 120 mL of hydrochloric acid solution in a 250 mL beaker
4. **To clean the burette** - make sure it is closed and, using a funnel, pour about 10 mL of the hydrochloric acid solution into the burette. Place the burette in a burette holder on a retort stand and place a catch beaker under the spout of the burette and let the hydrochloric acid run through. Repeat this procedure twice more using new 10 mL samples of hydrochloric acid each time.
5. Refill the burette so that the meniscus of the hydrochloric acid solution is above the 0 mL mark and let the excess solution run out so that the meniscus eventually rests on the 0 mL mark. If there is a drop of solution hanging on the burette tip, remove it by touching the drop to the inside wall of the 250 mL Erlenmeyer flask.
6. Obtain 120 mL of sodium hydroxide in another (clean!) 250 mL beaker.
7. Pipette 25 mL of the sodium hydroxide into the Erlenmeyer flask.
8. Place 3 drops of phenolphthalein into the Erlenmeyer flask that contains the base.
9. Place the Erlenmeyer flask under the burette.
10. Slowly add hydrochloric acid from the burette, one mL at a time. Stop after every 1 mL addition to swirl the solution in order to make sure that the acid is properly mixed with the base. You will start to see the pink color change. When you get the sense that you are getting close to the endpoint **add the acid** **drop by drop and swirl continuously so that you don’t miss it.** The endpoint has been reached (or passed) when the indicator changes color permanently. The endpoint will occur suddenly and you may overshoot it the first time you do the titration. If you think you passed the endpoint by several drops redo the titration before recording the volume of acid added.

11) Repeat the titration (steps 7 – 10) twice more. Do not refill the burette unless you have run out of acid. Record the initial reading of the burette and add acid from that point. Record all of your data. Calculate the average volume of acid added.

**Observations:**

Titrations with indicator:

|  |  |  |  |
| --- | --- | --- | --- |
| Measurements | Trial #1 | Trial #2 | Trial #3 |
| Concentration of HCl (mol/L) |  |  |  |
| Volume of NaOH (mL) |  |  |  |
| Initial reading of acid on burette (mL) |  |  |  |
| Final reading of acid on burette (mL) |  |  |  |
| Total volume of HCl added (mL) |  |  |  |
| Average Volume of HCl added (mL) |  | | |

1. What color is the indicator phenolphthalein in an acidic solution and in a basic solution?

1. Why does the clear color, which forms at the point where the hydrochloric acid comes into contact with the solution containing phenolphthalein and base in the receiving flask, disappear more slowly near the endpoint?

1. What ions are taking part in the neutralization reaction?

1. In terms of the ions present, what has happened at the endpoint of the titration?

1. Why is it a good idea to carry out titrations in triplicate?

1. Would the addition of several milliliters of distilled water to the Erlenmeyer receiving flask during a titration affect the results of the titration? Explain your answer.

**One peer activity to illustrate the concept with class on line participation**

PEER ACTIVITY: The pH Rainbow Column (adapted from Chemistry 11 Nelson)

**In this activity you will use the color changes of Universal Indicator to monitor the neutralization of an acid with a base. (Universal indicator is an acid-base indicator that undergoes several color changes as its pH changes.)**

Equipment and Materials:

**Chemical safety goggles, lab apron, large test tube, Berol pipette, two 150 ml beakers, test tube rack, dropper bottles containing saturated sodium carbonate solution, dilute hydrochloric acid (0.1mol/L) and universal indicator solution.**

Safety precautions:

**The solutions of sodium carbonate and hydrochloric acid are both irritants. Avoid skin contact. If some does spill on your skin, wash the affected area with plenty of cool water. Report any spills to your teacher.**

Procedure:

1. **Put on your safety goggles and lab apron.**
2. **Fill the test tube to within 4 cm of the top with hydrochloric acid. Pour the acid into a beaker.**
3. **Add about 5 drops of universal indicator solutions to the acid in the beaker. Swirl to mix.**
4. **Carefully pour the contents of the beaker back in to the test tube. Record your observations.**
5. **Pour about 50 ml of sodium carbonate solution in the second beaker. Fill the pipette with this solution.**
6. **Tilt the test tube slightly. Slowly add the sodium carbonate solution to the test tube. This solution sinks to the bottom.**
7. **Place the test tube in to the test tube rack and observe.**
8. **Dispose of all the chemicals and wash your hands thoroughly.**

Table 1: Universal Indicator Colors

|  |  |  |
| --- | --- | --- |
| **Color** | | **Solution is …..** |
|  | **Red** | **Very acidic** |
|  | **Orange/yellow** | **Moderately acidic** |
|  | **Green** | **Neutral** |
|  | **Blue** | **Moderately basic** |
|  | **Purple** | **Very basic** |

**Assessment & Evaluation**

**Quiz** on Acids and Bases (Knowledge/Understanding) **Pre Lab** Revise Lab Safety Rules **Formal Lab** Acid – Base Titration (Thinking/Inquiry) **Activity** for strong and weak acids and bases (Inquiry/investigation) **Reflective Response** on Demonstration (Communication) **Lab Report** (Titration/Inquiry) (Communication)

**Culminating Task** Rubric forresearch project and oral presentations (Communication, Application)

**Unit Test** (Knowledge/Understanding, Application, and Communication) with emphasis on Application of the concepts learned.

**Advanced Preparation**

Review safety procedures

Collect all the materials required

The teacher should do the demonstration himself/herself before doing it with the students Remember to add Acid to Water not Water to Acid

**Practical Applications and Societal Implications**

* Softening of water using soda lime process by municipalities and wastewater treatment.
* Neutralization has many practical applications. Reclamation (restoration) of land once used for mining also involves neutralization reactions
* Neutralization is also used to deal with environmental problems.
* Acids and bases are used in the manufacture of fertilizers, synthetic fabrics, pigments, petroleum, iron and steel, explosives, dyes, plastics, pesticides, soaps and detergents, paper, film, and many other chemicals
* They are also used for various other purposes, including cleaning surfaces, refining oil and sugar, electroplating metals, and treating food products.
* Sulfuric acid is the chemical most widely used in industry.
* Nitric acid, another important industrial acid, is used in the manufacture of fertilizers, plastics, photographic film, and dyes and explosives as dynamite and TNT.
* Hydrochloric acid is used to clean metals, brick and tile; it is used in the manufacture of sugar and glue.
* pH plays an important role in the chemistry of the body.

##### **Internet Sites**

[**http://www.scienceclarified.com/A-Al/Acids-and-Bases.html**](http://www.scienceclarified.com/A-Al/Acids-and-Bases.html)

This web site is an excellent resource to find practical applications of acids and bases.

<http://www.sciencebyjones.com/acids_bases_salts.htm>

This web site leads to different areas of interest such as properties, definitions, questions and problems about acids and bases.

<http://www.ehs.pvt.k12.ca.us/projects/9798/science6/Stephanie>

This is a web page containing information about litmus and pH

<http://www.chembio.uoguelph.ca/educmat/chm19104/chemtoons/chemtoons.htm>

The variety of animations about acids and bases are self-explanatory

<http://www.youtube.com/watch?v=PCM5IwJ8wcs>

A very informative video on acids and bases

<http://www.visionlearning.com/library/module_viewer.php?mid=58>

This site is a step by step guide to teach acids and bases

<http://library.thinkquest.org/10429/low/acidbase/acidbase.htm>

This web site is an excellent source to learn about the theories of acids and bases.